A STRATEGY FOR THE DEVELOPMENT OF A WEB-BASED TOOL TO REDUCE AVIATION MAINTENANCE ERRORS

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The safety and reliability of air transportation depends on minimizing inspection and maintenance errors that occur in the aircraft maintenance system. Efforts have been invested to track maintenance errors. These efforts are reactive in nature: they analyze maintenance errors after their occurrence. There is a lack of standardization in the assessment of maintenance errors across the maintenance industry. Surveillance and auditing of maintenance activities are two important functions which help ensure airworthiness of an aircraft. A system that will document the processes and outcomes of these maintenance activities and will make this documentation more accessible will accomplish the goal of this research to reduce maintenance error. Such a system would then support robust and safer aircraft maintenance operations. Our research is developing a web-based surveillance and auditing tool (WebSAT) that promotes a standardized format for maintenance data collection, reduction and analysis to proactively identify the factors contributing to improper maintenance.

INTRODUCTION

The aircraft maintenance system is complicated (Gramopadhye, Drury and Prabhu, 1997), with interrelated human and machine components. Realizing this, the FAA has pursued human factors research for some time now under the National Plan for Aviation Human Factors (FAA, 1991; FAA, 1993) to fulfill the mission of the FAA's Flight Standards Service of promoting safety by setting certification standards for air carriers, commercial operators, air agencies, and airmen.

A study conducted by Boeing and the US Air Transport Association (1995) found that maintenance error was a crucial factor in aircraft accidents from 1982 to 1991, contributing to 15% of the commercial hull loss accidents where five or more people were killed. Rankin and Allen (1995) established the economic costs of these maintenance errors, estimating that 20 to 30% of in-flight shutdowns are due to maintenance error, 50% of flight delays are due to engine problems caused by maintenance errors, and 50% of flight cancellations are due to engine problems caused by maintenance errors. The need is apparent for a proactive system which will help track maintenance errors, identifying both potential problem areas and the factors causing errors. If such a system is developed it will be possible to better manage maintenance errors, resulting in aircraft maintenance which is safer and more robust.

Problem Statement

To minimize maintenance errors, the aviation maintenance industry has developed methodologies to investigate maintenance errors. The literature of human error is rich, having its foundations in early studies analyzing human error made by pilots (Fitts and Jones, 1947), human error work following the Three Mile Island accident, and recent research in human reliability and the development of error taxonomies (Norman, 1981; Rasmussen, 1982; Reason, 1990; Rouse and Rouse, 1983; Swain and Guttman, 1983). This research has centered on analyzing maintenance accidents and incidents, a recent example being the Maintenance Error Decision Aid (MEDA) (Rankin, Hibit, Allen and Sargent, 2000). This tool, developed by Boeing along with representatives from British Airways, Continental Airlines, United Airlines, the International Association of Machinists and the US Federal Aviation Administration, helps analysts identify the contributing factors leading to an accident. Various airlines have developed internal procedures to track maintenance errors. One such methodology is the failure modes and effects analysis approach (Hobbs and Willamson, 2001) that classifies potential errors by expanding each step of a task analysis into sub-steps and then listing the potential failure modes. The US Naval Safety Center developed the Human Factors Analysis and Classification System- Maintenance Extension Taxonomy and the follow-up web-based maintenance error information management system to analyze naval aviation mishaps (Schmidt, Schmorrow and Hardee, 1998; Shappell and Wiegman, 1997, 2001) and later used to analyze commercial aviation accidents (Wiegman and Shappell, 2001). Although valuable in terms of their insights into performance-shaping factors leading to maintenance errors following their occurrence, these efforts are reactive in nature. Maintenance error tracking efforts are also ad hoc in nature, varying across the industry with little standardization. The lack of standardization in data collection, reduction and analysis is the single biggest drawback in the analysis of maintenance errors within and across the maintenance industry. This research is developing a web-based surveillance and auditing tool (WebSAT) that promotes standardized data collection and analysis. Surveillance, auditing, and airworthiness directives are the activities which will be the primary data sources for WebSAT, as shown in Figure 1.

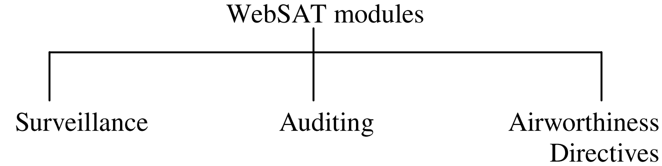

Figure 1. Data sources for WebSAT

Surveillance maintenance vendor and fuel vendor surveillance activities will form the basis for our inputs on surveillance activities. Technical audits, internal audits, self audits, and fuel, maintenance and ramp audits will form the basis for inputs on auditing activities. Airworthiness directives data will be derived from work instruction cards and engineering orders. For the purpose of illustration, we use surveillance activity as an example to describe our initial development efforts in this paper.

Surveillance: Surveillance is the day-to-day oversight and evaluation of the work contracted to an airframe substantial maintenance vendor or fuel vendor to determine the level of compliance with the airline's Continuous Airworthiness Maintenance Program (CAMP) and General Maintenance Manual (GMM). The objective of surveillance is to provide the airline, through the accomplishment of a variety of specific surveillance activities on a planned and random sampling basis, an accurate, real-time, and comprehensive evaluation of how well each maintenance vendor is complying with airline and FAA approved policies and regulatory requirements. WebSAT will perform surveillance activities to ensure that a consistent level of supervision is maintained over maintenance and inspection operations. The system will seek input from various sources, including In-Process Surveillance, Verification Surveillance, Final Walk Around, Aircraft Walk Around, Inspection, Storage, among others, as shown in Figure 2.

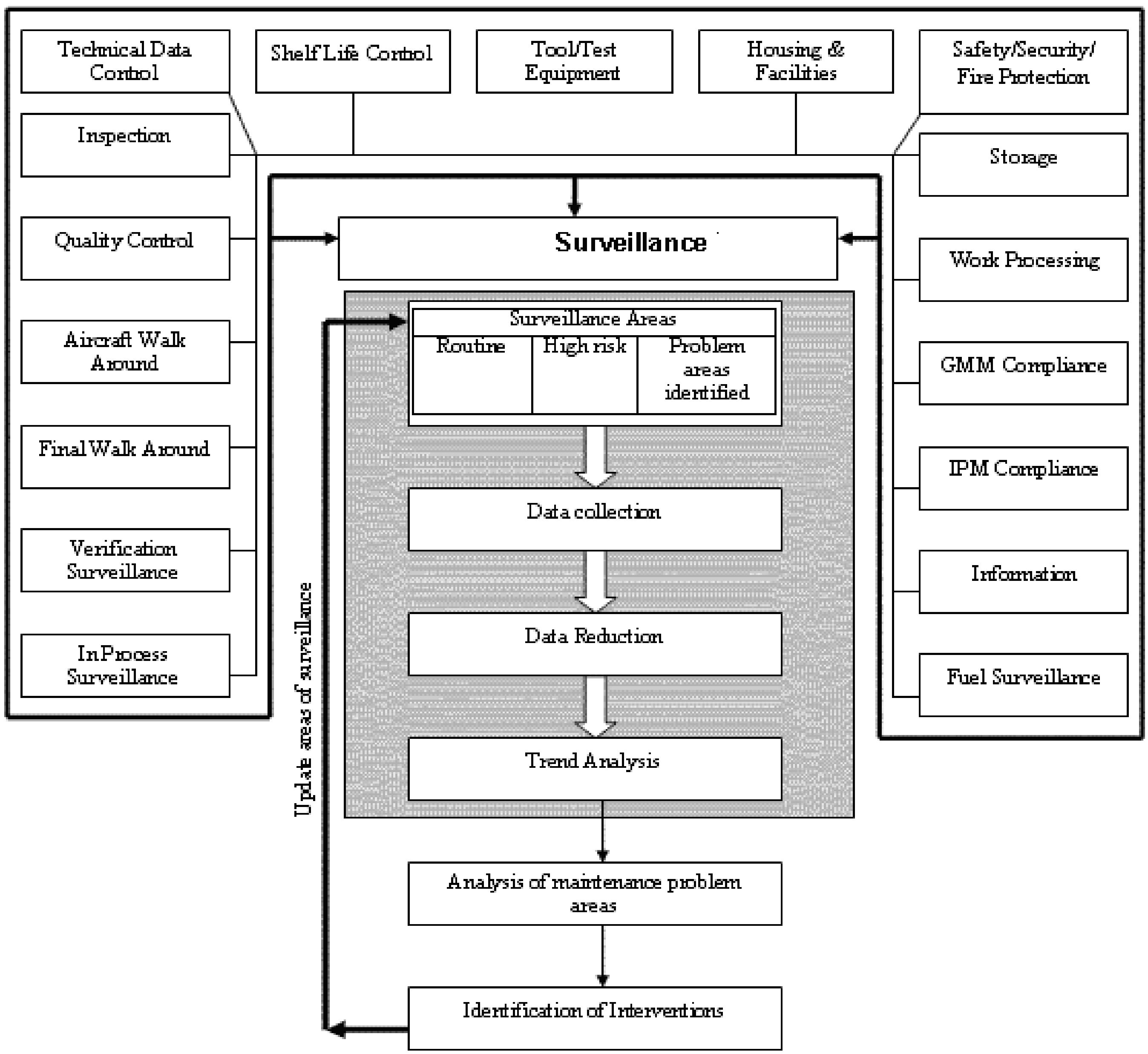

Figure 2. Data sources involved in a surveillance activity

These are the sources which provide the most information about maintenance and inspection errors and hence are termed the potential impact variables that affect the performance of the surveillance activity. Similar variables are being identified for the other activities mentioned in Figure 1, namely auditing and airworthiness directives.

Data collected from these diverse sources will be analyzed to identify potential problem areas. The identification of these problem areas will let the industry prioritize factors that transcend the individual airlines to systematically reduce or eliminate potential errors. The WebSAT system is being developed with a specific aviation partner (FedEx in Memphis, TN) to ensure the needs of the aviation community are addressed. It will be made available as an application that can be downloaded for use by each maintenance facility.

METHODOLOGY

The research is being conducted in three phases.

Phase 1: Identification of Impact Variables and Data Sources.

- Identify the 'impact variables' that affect the performance of maintenance surveillance and auditing activities.
- Ensure that the identified variables are representative of those used by most maintenance entities.
- Identify the limitations in using the specific impact variables identified.

The first phase of the research will finalize the list of impact variables.

Phase 2: Develop Prototype of Auditing and Surveillance Tool

- Product phase: The research team will achieve consensus on the project mission statement.
- Needs analysis phase: In this phase the researchers will gather data, identify customer needs, and establish the relative importance of the needs.
- Product specifications phase: The researchers will develop a preliminary set of target specifications.
- Conceptual design phase.
- Concept generation and selection phase.
- Detail design of selected concept to create an initial working prototype.
- Testing and refinement of the initial working prototype with representative users.
- The delivery of a refined prototype to FedEx for trial use.

Phase 3: Develop Data Analysis and Validation Module

- Develop advanced data analysis tools that include multivariate analysis and risk assessment.
- Validate using field data.

WEBSAT RESEARCH FRAMEWORK

The WebSAT research framework shown in Figure 3 has 3 tiers associated with it. In tier 1, relevant data collected from the three modules (surveillance, auditing and airworthiness directives) will be analyzed using the identified process measures which allow us to evaluate the effectiveness of each module.

Further analysis of data will lead us to the categories in tier-2 which evaluates the performance of the airline across the three modules. These categories are factors such as cost, economy, etc. which have a direct bearing on the impact on the safety of an airline.

Our research team will then conduct analysis of tier-2 and estimate safety index of the airline by identifying the risk-causing factors represented in tier-3. In tier 3 it is demonstrated that the variables are of 2 kinds: risk and non-risk. The upper management is interested in the risk or impact variables, which will be indicated by the tool. The research team finds it appropriate to report results of analysis for non-risk or ordinary variables, contemplating that useful input will be generated.

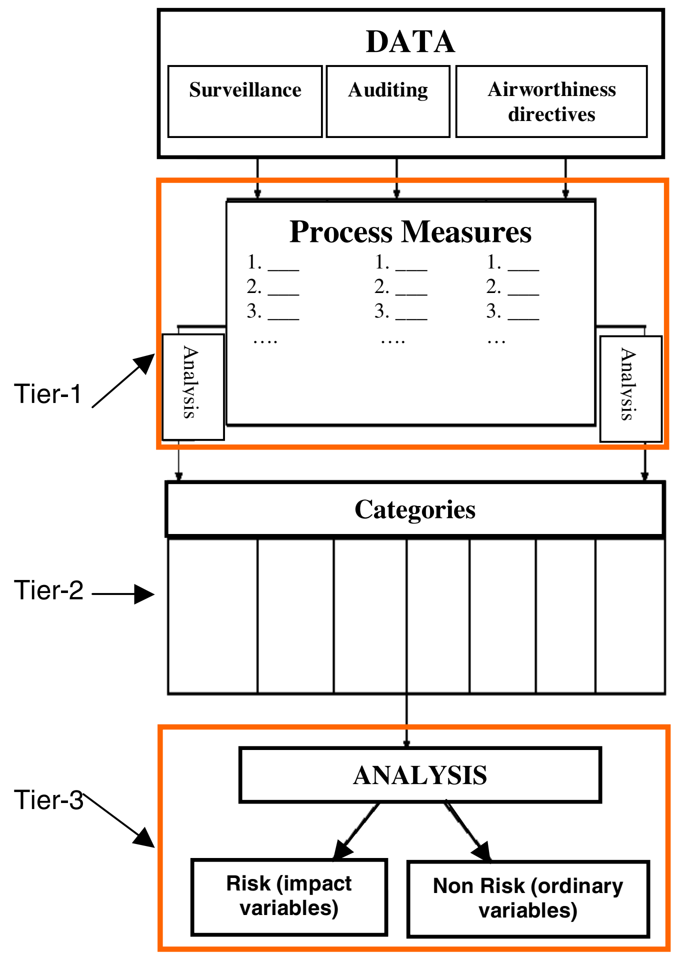

Figure 3. WebSAT Framework Prototype

SIGNIFICANCE AND IMPACT OF WEBSAT

The development of a web-based surveillance and auditing tool has the potential to reduce maintenance errors impacting aviation safety. The specific advantages of this tool are the following: (1) a proactive approach reduces maintenance errors by identifying problem areas and error contributing factors; (2) the adoption of this tool by the aircraft maintenance industry promotes standardization in collection, reduction and analysis of maintenance error data; (3) this standardization will result in superior trend analysis of problem areas; and (4) the findings can be shared by manufacturers, airlines, repair stations and air cargo handlers to identify and prioritize factors which lead to maintenance errors.

CONCLUSION

In summary, the objective of this research is to: (1) identify an exhaustive list of impact variables that affect aviation safety and transcend various aircraft maintenance organizations; (2) design and develop web-based surveillance and auditing tool which uses the identified set of impact variables for data analysis. The results of this research will be disseminated to the aviation community via a number of avenues. These include scholastic publications and training software available for download from the FAA's web site and the regular communication of the results of this research to industry partners.

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